Lab: INTRODUCTION TO MINERAL PROPERTIES

Introduction

Rocks and other earth materials we will study in this course are made up largely of minerals. Because minerals are the basic building blocks of most geologic materials, an understanding of minerals is therefore important to our study of geology.

In this course you will learn how to identify minerals by means of their more obvious physical properties. The next several pages constitute an introduction to minerals, their physical properties, and the techniques by which they can be identified. It is important that you carefully read this material and be familiar with it before coming to class.

We will discuss this material once in class, and from then on you will be held responsible for knowing it in subsequent lab sessions, quizzes and for examinations. In the coming weeks, you will be using this information repeatedly to identify the mineral unknowns in your mineral tray. Therefore, keep this introduction handy until you thoroughly understand it. Much of this material is covered in your well-illustrated but extremely expensive textbook. You are encouraged to USE IT! In addition, there are numerous examples of crystal habit form, cleavage, textures and other mineral properties in the display case located along the west wall of the geology study room (E210).

Introduction to Minerals

I. **Definition of a Mineral:** A naturally occurring solid substance having a regular, orderly arrangement of atoms and a more or less definite chemical composition (or range of compositions) that can be expressed as a chemical formula.

II. **Internal Structure of Minerals**: The internal structure of a mineral is the pattern in which its atoms, ions or molecules are arranged to form a crystal structure.

The importance of internal structure may be illustrated by the two minerals diamond and graphite. These two minerals are as different in their physical characteristics as any can be, yet both are made entirely of carbon atoms. Diamond is the hardest of all naturally occurring substances, is transparent if pure, and has an adamantine luster. Graphite, on the other hand, is opaque, black, and so soft that it has a greasy feeling and rubs off easily. It is mixed with clay to make "lead" in pencils. Diamond and graphite are “polymorphs”.

All crystalline substances, including minerals, grow by the addition of atoms or other particles in a systematic order, much as a bricklayer lays a wall. If crystals have room to grow, they will tend to form smooth, flat faces with exact angles between them, producing regular geometric shapes. Often a crystal will tend to break in a regular way, controlled by its internal structure. However, when mineral crystals from in nature, they often interfere with each other and flat faces have no room to form. Nevertheless, they are still crystals because of their orderly internal arrangement.

III. **Chemical Composition:** The chemical composition of minerals can be specified by a chemical formula. For example, quartz is always SiO_2 meaning there are two atoms of oxygen (O) for each atom of silicon (Si) in the mineral. But some minerals can include a range of compositions. For example, olivine [$(Fe, Mg)_2SiO_2$] has a range of compositions with varying amounts of iron (Fe) and magnesium (Mg).

IV. **Physical Properties of Minerals**

A. **Hardness** - Hardness is the scratchability of a substance. If one mineral can scratch another, the one that does the scratching is harder. Two minerals of equal hardness will either both scratch each other or both fail to scratch each other. The following minerals form a standard scale of relative hardness for minerals called the Mohs' Hardness Scale

1. Talc - A mineral very easily scratched with a fingernail. Often has a slippery feeling.

2. Gypsum - A mineral that can be scratched by a fingernail, but not as easily as talc.

3. Calcite - A mineral easily scratched with a knife blade, not scratched by a fingernail. The common rock limestone is made of calcite.

4. Fluorite - A mineral scratched with more difficulty by a knife blade.

5. Apatite - Difficult to scratch with a knife blade. Apatite is rare in large pieces, but occurs frequently in microscopic crystals scattered through common igneous rocks. When rocks weather, it produces an important fertilizer (phosphate).

6. Feldspar (Orthoclase, Plagioclase or Microcline) - A mineral family that cannot be scratched by a knife blade, but can be scratched by quartz. Common minerals in igneous rocks.

7. Quartz - The hardest common mineral. Because it is resistant to weathering, quartz remains fresh. It is the best known mineral to the general public.

8. Topaz - A mineral too hard for quartz to scratch. Considerable pressure is required to scratch hard minerals.

9. Corundum - Next to the diamond, the hardest mineral. Rubies and sapphires are varieties.

10. Diamond - Nothing in nature but another diamond will scratch diamond.

Compared to the minerals above, fingernails have a hardness of 2.5, a penny is 3-4, knife blades are about 5.5, and streak plates are about 7.

B. Color - Color is the least reliable of all the physical properties because differences in grain size, minute amounts of impurities and other variations may cause changes in a mineral's normal color. Many minerals are the same color and a single mineral can be many colors.

C. Luster - Luster is the way a mineral reflects light. There are two main classifications of luster, metallic and nonmetallic.

1. **Metallic** - A luster is metallic only if it resembles a metal (such as iron, bronze, lead, silver or gold) so much that it might be confused with it. Metallic minerals are opaque – that is, no light penetrates the mineral.

2. **Nonmetallic** - These minerals are those which do not look like metal. Their luster is futher described by the following terms:
   - Adamantine - reflects light brilliantly, like a diamond.
   - Vitreous (or glassy) - reflects like glass, although the mineral may be opaque.
   - Pearly - like mother-of-pearl.
   - Resinous - the luster of dried pitch, or fiberglass resin.
   - Waxy - luster of freshly waxed surface, or a broken candle.
   - Oily - luster of oil.
   - Silky - luster of silk or satin cloth.
   - Dull or earthy - as indicated.

D. Streak - Streak is the color of the powdered mineral. It is especially significant when different from the color of the unpowdered mineral. The streak can be determined most easily by scratching across an unglazed porcelain plate (streak plate). If the mineral is harder than the plate, the streak can be found by crushing a small piece of the mineral to powder.

E. Cleavage - Cleavage is the ability of a mineral to break along a specific direction or plane. It is a break between planes of tiny particles in a mineral's internal structure.

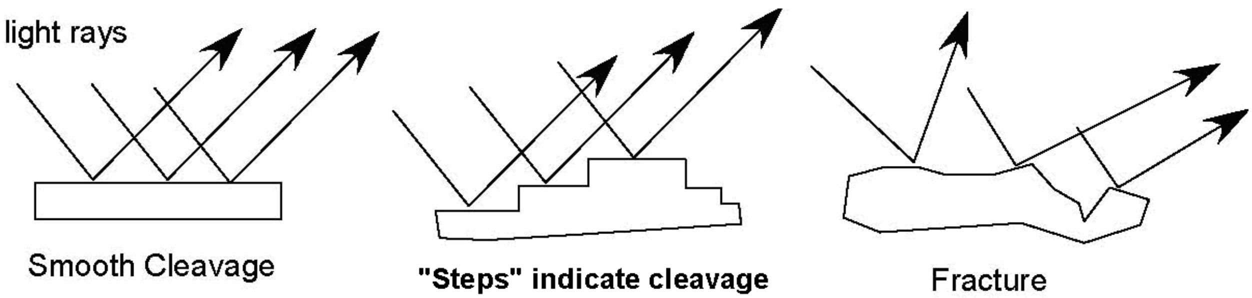
Some minerals have no cleavage; some have only one direction of cleavage; other have two or more directions, producing surfaces that are not parallel. Each cleavage direction may produce many parallel surfaces, most often one on the top and one on the bottom of the specimen, or cleavage may appear as a series of parallel steps which all reflect light at the same angle. When there are two or three directions, it is important to note whether they are perpendicular of oblique to each other. Count every cleavage on a single crystal that is not parallel to one already counted.

When describing cleavage always include:

1. How many directions of cleavage are present.
2. Angular relationships between the directions (90° or oblique)
3. Quality of cleavage (perfect, good or poor).

Discussion of Cleavage

The forces which hold the atoms together in a crystal are not necessarily equal in all directions. If definite planes of weakness exist, the mineral will cleave or break along those planes much more readily than in other directions. The surface along which the break develops is referred to as a *cleavage plane*, and the orientation of the plane is the *cleavage direction*. Perfect cleavage is easily recognized because it characteristically develops a smooth, even surface which will reflect light like a mirror. However, cleavage planes may occur in a step-like manner and appear at first to be an irregular fracture. If the specimen is rotated in front of a light, the small parallel cleavage planes will reflect light in the same manner as a large smooth cleavage surface. An uneven fracture will not concentrate light in any particular direction

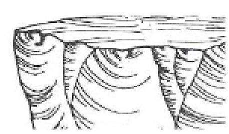


Remember the distinction between cleavage planes and crystal faces! Cleavage results from planes of weakness within the crystal structure along which the crystal breaks. Crystal faces reflect the geometry of the structure, but form only when the mineral can grow without "bumping into" other crystals. Both are properties of single crystals. In a crystalline aggregate, the individual crystals will break along their own cleavage planes (if any exist) but an aggregate itself does not possess cleavage. If you have a flat surface on a mineral grain, and you do not know if it is a crystal face or a cleavage, you can determine this by breaking off a small corner or seeing where one has been chipped off the edge of this flat surface. If you have broken off the corner of a crystal face with no cleavage, you will observe an uneven break. If you break off the corner of a cleavage plane, you will find that the break actually consists of several steps with planar surfaces parallel to the original surface which was broken off.

In some minerals the crystalline structure is so well bonded together that there is no tendency to break along one plane in preference to any other. Such minerals do not possess cleavage, but break (or fracture) in an irregular manner.

F. **<u>Fracture</u>** - Any break which is not a cleavage is called a fracture. A fracture is not predetermined by the arrangement of atoms in the mineral and is usually irregular.

"Conchoidal" is a special type of fracture which produces a smooth curving break as seen in broken glass.



G. **Crystal Form or Specimen Structure** - Every mineral specimen encountered will belong to one of the following three classes and one of their subheadings:

1. **Whole crystal** (crystal form): If you have a whole crystal or enough of it to recognize its characteristic shape, that is a very significant property to note. Several characteristic forms are: cubes, octahedrons, dodecahedrons, hexagonal prisms, hexagonal pyramids, etc. If there are many faces, making a shape which is not easily recognized, report it as a complicated crystal.

2. **Less than one crystal**: If the specimen does not show enough crystal faces to identify its crystal form, but gives an indication (such as a single crystal face going all the way across it, or a cleavage face showing a light flash) which shows it all belongs to a single crystal, then call it either:

- Cleavage fragment - if the specimen is bounded mostly by cleavage planes that give flashes of light (this is a very common form of many mineral specimens).
- Fracture fragment - if it is bounded mostly by irregular or curving fractures.

3. **Many crystals grown together (aggregate)**: If you can see many individual grains or a mass that show no recognizable arrangement, identify it as one of the following aggregate specimen structures:

- Granular – made of grains large enough to recognize some of their properties.
- Massive - applies to a mass of tiny little grains (crystals), so small that the individual properties of the grains cannot recognized.
- Microcrystalline - crystals too small to be seen with a handlens. Can often be recognized by conchoidal fracture and waxy luster.
- Fibrous (or acicular) - means long thin crystals which may be parallel, radiating, or crisscrossing.
- Elongated - crystals which are longer in one direction than the others and larger than fibrous. If shaped like the blade of a sword, they are called *bladed*.
- Tabular, platy or in laminae - applies to crystals that grow originally in thin flat shapes, usually intergrown in different positions. If they are all lying the same way and have been squeezed together like a pile of wet leaves, they are called foliated.
- Aggregates of microcrystalline crystals may have rounded or curved surfaces. There are several varieties:
    - Oolitic - tiny rounded masses the size BB's. (<2mm)
    - Pisolitic - rounded masses the size of a pea or salmon egg. (>2mm)
    - Nodular - irregular shaped masses about the same size as pisolitic.
    - Botryoidal - the size of grapes in a bunch.
    - Reniform or mammillary - broad curves like the surface of a kidney or composed of breast-shaped or rounded protuberances.

H. **Heft (specific gravity) -** Record heft as either light, medium, or heavy in comparison with specimens of other minerals of the same size. For convenience, heft can be considered as the relative weight of a specimen.

I. Miscellaneous Properties

A. Transmission of light

- Transparent - can see distinctly through the mineral.
- Translucent - can see light but not objects through the mineral.
- Opaque – no light passes through the mineral.

B. Taste – halite is salty for example

C. Smell – sulphur smells like rotten eggs for example

D. Feel - mineral is gritty, soapy, etc. when rubbed with your finger.

E. Structural varieties

- Flexible - can be bent, but will not return to original shape when released.
- Elastic - will return to original shape after bent and released.
- Sectile - can be cut with a knife into thin sheets.
- Malleable - can be hammered into shapes other than that of the original.
- Brittle - easily broken or shattered.

F. Magnetism - Magnetic minerals are attracted to a magnet.

G. Twinning - appears as one crystal growing through the other (or as in the case of plagioclase appears as striations on a cleavage face).

WARNING: Do not record anything as a miscellaneous property that properly belongs in some other category.

MOH'S HARDNESS SCALE MINERALS - EXERCISE

The minerals in this lab exercise are nine of the ten minerals that make up Mohs' hardness scale. In this exercise you will learn to recognize and describe the various mineral properties. In future exercises you will use these skills to identify unknown minerals.

Procedure

1. Arrange the nine minerals in order of increasing hardness. You do this by scratching one with the other to see which one is the harder. Once you have arranged the minerals, ask your instructor to check your arrangement before continuing. You are expected to be able to do this on your own in future labs – they will be your tool for determining the hardness of other minerals.

2. Fill in the physical properties for each mineral on the mineral identification form. Do each carefully and completely. Complete each mineral before moving on to the next. Remember: you are learning observation skills you will use in several future labs. Ask your instructor lots of questions. There are example specimens of the physical properties in the classroom and in the study room (E-210)

3. Once your ID form is completed check your observations in the Mineral Identification Table (found in your lab manual). Note that the Mineral Identification Table has two sections; one for metallic luster followed by one for nonmetallic luster. Within each section the minerals are listed in order of increasing hardness. Some of the properties on your form won't match those in the table. You should determine the reason for any discrepancies between your description and that given in the table. Also, be aware that the table may describe several possibilities for color and specimen structure, and your sample is just one example. Pay particular attention to errors you may have made in hardness and cleavage.

   If you find that you are consistently having trouble with one or more of the various properties it would be wise to check with your instructor just to see if you are making at the correct observations. Once you have completed your study of the physical properties of each of these nine minerals, you should be sufficiently familiar with the properties of minerals to be able to study a new unknown mineral and be able to identify it on the mineral table.

You should now go back and again review the properties of these nine minerals of Mohs' hardness scale. They are the minerals that you will use to determine the hardness of all of the unknown minerals in future lab exercises. You are expected to memorize the names, hardness, and some of the more important physical properties of these nine minerals. These minerals will be included in the Mineral Exam.

Mineral Identification Form

#	Hard-ness	Luster	Color	Streak	Specimen Structure	Cleavage or Fracture	Heft	Misc. Properties	Name & Chemical Formula